JETISH: Journal of Education Technology Information Social Sciences and Health
E-ISSN: 2964-2507 P-ISSN: 2964-819X
Vol. 2 No. 2 September 2023

Increase in CEC, K-dd, K Uptake, Si-Total, and Yield of Lowland Rice (Oryza sativa L.) Due to Different Doses of Organic and Inorganic Fertilizers on Ultisol

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Abstract

The addition of N, P, K, Nano-Silica, and Straw Compost is useful for providing the macro and micro nutrients needed by paddy rice plants. Lowland rice that is commonly cultivated by farmers is the Ciherang variety. In lowland rice cultivation activities, it is often found that plants are deficient in nutrients, especially in planting media that have a fairly high acidity content, namely soils of the Ultisol order. This study aims to determine the optimal fertilization of N, P, K, Nano-silica, and Straw Compost to increase CEC, K-dd, K Absorption, Si-Total, and Lowland Rice Yields on Ultisol soils. This research was conducted from September to December 2022 at the Soil Chemistry and Plant Nutrition Experimental Field, Faculty of Agriculture, Padjadjaran University, Jatinangor, Sumedang, West Java, at an altitude of 723 meters above sea level. The experimental design was carried out using a randomized block design (RBD) consisting of ten treatments and three replications. Treatment consisted of Control (Without N, P, K, Si and Straw Compost); Straw Compost (5 tonnes per hectare) + ½ N, P, K, Si; Straw Compost (5 tons per hectare) + 1 N, P, K, Si; Straw Compost (5 tonnes per hectare) + 1½ N, P, K, Si; Straw Compost (10 tons per hectare) + ½ N, P, K, Si; Straw Compost (10 tons per hectare) + 1 N, P, K, Si; Straw Compost (10 tonnes per hectare) + 1½ N, P, K, Si; Straw Compost (15 tonnes per hectare) + ½ N, P, K, Si; Straw Compost (15 tonnes per hectare) + 1 N, P, K, Si; Straw Compost (15 tonnes per hectare) + 1½ N, P, K, Si. The results showed that the combination of fertilizer doses of 1 N, P, K , Nano-silica and 10 tons per hectare of Straw Compost gave the highest rice yield with a dry harvested grain weight of 11.00 g.plant-1.

Keywords: Ultisol, Potassium, Organic Fertilizer, Inorganic Fertilizer

INTRODUCTION

Indonesia has soil of the Ultisol order which is a type of soil that can be developed in various topography, ranging from undulating to mountainous with high rainfall (Subagyo et al., 2004). Ultisols are widely distributed, covering almost 25% or 45,794,000 ha of the total land area and have great potential for use as agricultural land (Prasetyo & Suriadikarta, 2006). Ultisols are characterized by a deep cross-section of soil, a moderately acidic pH ($pH<4.5$), high $Al3+$ saturation and low base saturation (Adiningsih & Mulyadi, 1998). According to Sinukaban and Rachman (2008), Ultisol soil has chemical properties that can interfere with plant growth and production because it has low soil porosity, low to very low infiltration and soil permeability rates, aggregate stability and low soil water holding capacity. The chemical properties of Ultisol soil can also interfere with plant growth because it has an acidic pH with <5.0% high $Al3+$ saturation with >42%, low organic matter content with <1.1%, low nutrient content, namely N around 0.14%, P of 5.80 ppm, low base saturation of 29% and low CEC of 12.6 me.100 gram-1. Deficiencies in the physical and chemical properties of Ultisol soil can reduce the yield of paddy rice, so increasing productivity can be done by increasing the availability of nutrients and soil chemical properties.

Cation exchange capacity (CEC) is a soil chemical property that is closely related to the availability of nutrients for plants and reflects the ability of soil colloids to trap and exchange cations in the soil. CEC is exchanged in the colloid for the total amount of negatively charged cations. According to Danyai (2017), low soil organic matter content will have an impact on reducing soil humus content which will ultimately have an impact on low soil CEC. The size of the soil CEC value is influenced by soil reaction, texture or amount of clay, type of clay minerals, liming and fertilizing activities, and organic matter. The low CEC value is caused by a decrease in soil organic matter content as a result of physical activities in the soil (Ginting, 2017).

Research conducted by Yohana et al., (2013), showed that treatment of silica fertilizer with a mixture of organic fertilizers increased the element Si in the soil, but the effect was not significantly different. The addition of 20 ppm of colloidal nano-silica fertilizer in nutrient solution can increase Si absorption in rice plants by 5.19% of Si absorption in the control treatment (Amrulla, 2015). Research conducted by Nurmala (2018), shows that the application of 1 L/ha silica fertilizer can increase grain weight per clump, 1000 grain weight, grain length, grain width, and grain thickness (Nurmala, 2018). Efforts in providing a good fertilizer is to do balanced fertilization. In line with the Regulation of the Minister of Agriculture No. 40/Permentan/OT.140/4/2007 and No. 130/Permentan/SR.130/11/2014, this fertilization is as fertilizer for plants in accordance with the soil nutrient status and plant needs to achieve optimal and sustainable productivity. In fertilization there are nutrients that are absolutely needed by plants, namely Nitrogen (N), Phosphorus (P) and Potassium (K). In addition to these three essential elements, the element Silica (Si) is needed in large quantities by rice plants (Mulyani et al., 2018).

The Agency for Agricultural Research and Development (2020), recommends a single N, P, K fertilizer for rice plants in paddy fields, Jasinga District, Bogor Regency with 250 kg Urea, 100 kg SP-36, and 100 kg KCl per hectare. The application of straw compost at a dose of 10 tonnes per hectare according to research by Cut Salbiah et al., (2015) shows that the addition of straw compost is effective in increasing plant height, because it can contribute N nutrients needed by paddy rice plants. This dose became a reference in the research carried out because it adjusted the order of the soil used, namely Ultisol Jasinga soil and the recommended dose of fertilizer for upland rice planted in paddy fields was not much different from paddy rice. So, this research to find out the application of fertilizers with various combinations of inorganic fertilizers and organic fertilizers using N, P, K, Nano-Silica fertilizers and aga straw compost is expected to improve soil conditions by increasing CEC, K-dd, Si-Total, Si-plants, K absorption, and yields of lowland rice plants.

RESEARCH METHODS

The experiment was carried out in the soil fertility and plant nutritional experimental garden, Faculty of Agriculture, Padjadjaran University, Sumedang Regency with an altitude of ± 750 meters above sea level (MDPL) and laboratory analysis in the Lab. Soil Lab. given a layer of laying of 25 cm.

The treatment design used was a randomized block design (RBD) consisting of ten treatments with each treatment being repeated three times. The experimental unit carried out two observations, namely unit one on rice plants until the final vegetative phase which was used for soil analysis and plant analysis. Pelakuan yang dilakukan antaralain: A = Tanpa N,P,K, Si, dan Kompos Jerami; B = Kompos Jerami (5 ton per hektar) + ½ N,P,K, Si); C = Kompos Jerami (5 ton per hektar) + 1 N,P,K, Si); D = Kompos Jerami (5 ton per hektar) + 1½ N,P,K, Si; E = Kompos Jerami (10 ton per hektar) + ½ N,P,K, Si; F = Kompos Jerami (10 ton per hektar) + 1 N,P,K, Si; G = Kompos Jerami (10 ton per hektar) + 1½ N,P,K, Si; H = Kompos Jerami (15 ton per hektar) + ½ N,P,K, Si; I = Kompos Jerami (15 ton per hektar) + 1 N,P,K, Si; J = Kompos Jerami (15 ton per hektar) + 1½ N,P,K, Si. The addition of fertilizers given is in accordance with the recommendations for standard N, P, K fertilizers, namely 250 kg of Urea, 100 kg of SP-36, and 100 kg of KCl per hectare (BPPP, 2020), then organic fertilizers use straw compost with a recommendation of 10 tonnes per hectare. (Salbiah et al, 2013) and Nano Silica fertilizer (19.90%) with the recommendation of 1 L per hectare of liquid fertilizer mixed evenly in 500 L of water. At pre-planting, the planting medium was prepared by adding straw compost according to the treatment dose and incubating for 2 weeks. The first application of fertilizer after planting was carried out on plants aged 1 MST with Urea, KCl, and SP-36 according to the recommended dosage. In plants aged 3 and 6 WAP, Urea fertilizer was given again according to the recommended dosage. In addition, at 15 and 30 HST the plants were given nano-silica fertilizer according to the recommended dosage. Soil sampling was carried out for a chemical analysis test, namely at 67 HST or entering the maximum vegetative phase by separating all the soil from the roots of the rice and taking soil samples from all sides in a bucket. Prior to soil analysis, samples were prepared by homogenizing, drying, pulverizing and filtering. Chemical analysis in the laboratory, namely CEC with the distillation method, K-dd with the Flame-Photometer method, Potassium Absorption with Spectrometry, and Determination of Total Silica with the Ashing method. In addition, knowing the yield of paddy rice by counting and weighing harvested dry grain (GKP). Observational data were analyzed using a test of variance (ANOVA) at a significant level of 5%. Then, if the calculated F-value is greater than the F-table value, Duncan's multiple follow-up test is performed at a 5% significance level if there is a significant difference (Gomez ead et al., 1984.

RESEARCH RESULTS AND DISCUSSION

Supporting Observations

Preliminary Soil Analysis

Based on the results of the initial soil analysis before the experiment, the chemical soil fertility variables in Ultisol Jasinga were pH H2O (4.3) very acid and KCl (3.5) very acidic, C-organic (1.21%) low category, N-total (0.09%) very low category, C/N (13) medium category, P-available (4.9 ppm) very low category, P-potential HCl 25% P2O5 (13 mg.1 00mg-1) very low category. Cation exchange rate with Ca (5.42 cmol.kg-1) medium category, Mg (1.26 cmol.kg-1) medium category, K-dd (0.31 cmol.kg-1) medium category, Na (0.10 cmol.kg-1) low category. The CEC value (23.54 cmol.kg-1) was moderate, KB (20%) was low, Al3+ (16.27) and Al saturation (47%) was very high. Ultisols are a soil order that has acidity problems or low pH with an average of >4.5, low organic matter and low P, K, Ca, and Mg macro-nutrients. Mulyani et al. (2010), stated that the cation exchange capacity (CEC), base saturation (KB) and C-organic are low, the aluminum content is high value, P fixation is high, the content of Fe and Mn is close to the limit of plant poisoning and erosion-sensitive because it has poor drainage.

Experimental Environmental Conditions, Temperature, Humidity and Rainfall

Observations of temperature, humidity and rainfall were carried out every day during the experiment. The average temperature during the study ranged from 22.46–23.13°C. At the beginning of rice planting the ambient temperature is at 23.13°C, during growth the temperature ranges from 23.13–22.82°C and at the end of growth or harvest at 23.82°C. According to Kushawa (2016), rice plants have an optimum temperature during growth, namely the growth period is between 20-22°C at the beginning of planting, 23-25°C during the growth period and 25-30°C during the harvest. Conditions in the field do not yet have optimal temperatures for rice plants. Optimal temperatures can accelerate rice growth and respiration processes (Siswanti et al., 2018). In the implementation of research shows that humidity ranges between 87% -92%, namely in September 87%, October 90%, November 91%, December 92%, and January 89%. This humidity meets the requirements for growing rice plants because it has high average humidity.

Table 1. Effect of Application of Straw Compost and N, P, K, Nano-silica Fertilizer on CEC and K-dd in Ultisol Soil

Treatment		Cation Exchange Capacity	K-dd
		cmol.kg^{-1}	
A	Control	12,05 a	0,28 a
B	Kompos Jerami (5 ton per hektar) + ½ N, P, K, Nano-Silika	21,43 c	0,33 ab
C	Kompos Jerami (5 ton per hektar) + 1 N, P, K, Nano-Silika	25,09 cd	0,41 bc
D	Kompos Jerami (5 ton per hektar) + 1½ N, P, K, Nano-Silika	27,07 d	0,48 c
E	Kompos Jerami (10 ton per hektar) + ½ N, P, K, Nano-Silika	16,74 b	0,34 ab
F	Kompos Jerami (10 ton per hektar) + 1 N, P, K, Nano-Silika	21,42 c	0,42 bc
G	Kompos Jerami (10 ton per hektar) + 1½ N, P, K, Nano-Silika	23,53 cd	0,51 c
H	Kompos Jerami (15 ton per hektar) + ½ N, P, K, Nano-Silika	22,06 c	0,35 ab
I	Kompos Jerami (15 ton per hektar) + 1 N, P, K, Nano-Silika	22,68 c	0,45 c
J	Kompos Jerami (15 ton per hektar) + 1½ N, P, K, Nano-Silika	21,60 c	0,60 d

Note: The mean value followed by the same letter in the same column is not significantly different based on Duncan's multiple range test at level 5%.

In September, the average rainfall is 8.083 mm, October is 15.36 mm, November is 12.8 mm, December is 18.53 mm and January is 12.81 mm. In the category of conditions for growing rice plants have not been met. Therefore, the intensity of watering is carried out if the water conditions in the rice growing environment are dry enough, this is to maintain and provide water for the plants. Provision of water can directly affect rainfall conditions, as well as indirect effects, namely on conditions of temperature, humidity and sunlight intensity. Climate parameters will provide an overview of the conditions for plant growth and development, so if the growing conditions are met it will support optimal results for plants. The yield of rice plants is influenced by the intensity of sunlight. If it rains continuously, photosynthesis does not take place due to the lack of sunlight received by the plants. In September it was 82.75%, October 60%, November 56.01%, December 56.77% and January 60.22%. The parameter that has the greatest correlation during the generative period is the fertilization process, namely sunlight because it is needed for the formation of rice plant grains.

Main Observations

Cation Exchange Capacity and K-dd

Based on the results of the analysis of variance, it was shown that the application of straw compost organic fertilizer and inorganic fertilizers N, P, K, and Nano-silica made a significant difference to the Cation Exchange Capacity and K-dd of the soil as listed in Table 1 which was further tested by Duncan's multiple ranges with a level of 5%.

Cation Exchange Capacity

Treatment D (Straw Compost (5 tons per hectare) + 1½ N, P, K, Nano-Silica) had a significant effect on CEC in treatment A (Without N, P, K, Nano-Silica, and Straw Compost), but not significantly different in treatment C (Straw Compost (5 tons per hectare) + 1 N, P, K, Nano-Silica) and G (Straw Compost (10 tons per hectare) + 1½ N, P, K, Nano- Silica). Treatment D had a CEC value of 27.07 cmol.kg-1 which was higher than treatment A with a CEC value of 12.05 cmol.kg-1 and increased from the initial soil analysis which had a value of

23.54 cmol.kg-1. The difference in CEC values was influenced by differences in soil pH, treatment D showed a pH of 5.47 (slightly acidic) and had a pH value close to neutral compared to the other treatments, treatment A had a pH of 4.8 (acid) and initial soil analysis had a pH of 4.3 (acid).

Soil acidity affects the cation exchange that occurs in the soil. In soils that have a low pH, only the clay permanent charge and some of the organic colloidal charge can hold ions and be replaced through cation exchange, so the CEC value is relatively low. High clay content has a higher CEC than soils with low organic matter content or sandy soils (Hardjowigeno, 2007). The content of organic matter can decompose organic matter which will produce organic acids which give a negative charge to soil colloids thereby providing high cation adsorption. The low CEC in the Control treatment (Without N, P, K, Nano-Silica, and Straw Compost) occurred because there was no additional nutrient addition to the soil and nutrient leaching occurred. Organic matter can increase CEC by 20-70% which comes from humus colloids, so that it can increase the negative charge and the CEC will also increase (Pratama, 2022). Furthermore, according to the research of Siregar et al., (2017), states that CEC will increase if given the addition of organic matter which decomposes and produces humic compounds which contribute exchangeable colloids.

K-dd

Treatment A (without N, P, K, Nano-Silica, and Straw Compost) showed the lowest value compared to the other treatments, due to the absence of additional nutrients so that the K+ element needed in large quantities was not fulfilled. The increase in soil K-dd can be affected by the addition of organic fertilizers and inorganic fertilizers. Exchangeable cations (K-dd) have an effect on increasing the availability of K nutrients (Hanafiah, 2007). The amount of K nutrients needed is around 0.1% so that plants can grow well (Lakitan, 1993). The K-dd content had a positive effect with the addition of N, P, K fertilizer which was absorbed by paddy rice and the application of organic straw compost fertilizer increased the K-dd value, so that the J treatment (Straw Compost (15 tonnes per hectare) + 1½ N, P, K, Nano-Silica) had the highest value compared to the other treatments and at various doses it experienced an increase from the initial soil analysis with a value of 0.31 cmol.kg-1.

Table 2. Effect of Application of Straw Compost Fertilizer and N, P, K, Nano-silica Fertilizer on Si-Total Soil and Si-Poland Rice Plants

Treatment		Si-Total	Si-Tanaman
		%	$g.tanaman^{-1}$
A	Control	15,40 a	7,98 ab
B	Kompos Jerami (5 ton per hektar) + ½ N, P, K, Nano-Silika	19,07 c	5,98 a
C	Kompos Jerami (5 ton per hektar) + 1 N, P, K, Nano-Silika	21,82 d	7, 77ab
D	Kompos Jerami (5 ton per hektar) + 1½ N, P, K, Nano-Silika	35,24 f	10,72 cd
E	Kompos Jerami (10 ton per hektar) + ½ N, P, K, Nano-Silika	19,74 c	6,86 a
F	Kompos Jerami (10 ton per hektar) + 1 N, P, K, Nano-Silika	22,13 d	9,02 cd
G	Kompos Jerami (10 ton per hektar) + 1½ N, P, K, Nano-Silika	32,96 e	15,99 d
H	Kompos Jerami (15 ton per hektar) + ½ N, P, K, Nano-Silika	17,84 b	6,30 a
I	Kompos Jerami (15 ton per hektar) + 1 N, P, K, Nano-Silika	22,20 d	8,38 ab
J	Kompos Jerami (15 ton per hektar) + 1½ N, P, K, Nano-Silika	35,46 f	12,14 cd

Note: The mean value followed by the same letter in the same column is not significantly different based on Duncan's multiple range test at level 5%.

Si-Total Land and Si-Plants

Based on the results of the analysis of variance, it was shown that the application of organic compost straw fertilizer and inorganic fertilizers N, P, K, and Nano-silica made a significant difference to the Si-Total Soil and Si-Plants listed in Table 2 which has been tested for distance

Si-Total Land

Si-total analysis showed that treatments D (Straw Compost (5 tonnes per hectare) + 1½ N, P, K, Nano-Silica) and J (Straw Compost (15 tonnes per hectare) + 1½ N, P, K, Nano-Silica) were significantly different from Control A (without N, P, K, Nano-Silica and Straw Compost). This shows that the total Si content increased when treated with 1 ½ doses of N, P, K and Nano-silica fertilizers, compared to no fertilizer treatment. The treatment with the highest Nano-silica fertilizer application had the highest total soil Si content, namely treatment D (Straw Compost (5 tons per hectare) + 1½ N, P, K, Nano-Silica) worth 35.24% and F treatment (Straw Compost (15 tons per hectare) + 1½ N, P, K, Nano-Silica) worth 35.46%, this was due to the addition of silica content that was given to the soil through fertilization. The increase in the total Si content in the soil is thought to be due to the application of basic fertilizer in the form of straw compost which has a Si content of straw between 5-6% (Fairhurst, 2000).

The-Plant

Treatments A (Without N, P, K, Nano-Silica and Straw Compost), D (Straw Compost (5 tonnes per hectare) + 1 N, P, K, Si), F (Straw Compost (10 tonnes per hectare) + 1 N, P, K, Nano-Silica), and J (Straw Compost (15 tonnes per hectare) + 1½ N, P, K, Nano-Silica) were significantly different from treatment B (Straw Compost (5 tonnes per hectare) + ½ N, P, K, Nano-Silica), E (Straw Compost (10 tonnes per hectare) + ½ N, P, K, Nano-Silica), and H (Straw Compost (15 tonnes per hectare) + ½ N, P, K, Nano-Silica), but not significantly different between the treatments. This shows that the highest doses of N, P, K (1.5 g/ton), Nano-silica (6 mL/ton), and Straw Compost (80 g.ton-1) did not show significantly different results on the plant Si uptake values. It is suspected that the absorption of the nano-silica element that was given was not optimal and the dose that occurred was that the nano-silica that was applied had a fairly low concentration (19.90%). According to Wang et al., (2014), stated that the application of silica can control abiotic and biotic stresses, but does not have a direct effect on plant growth.

Potassium Uptake and Yields of Lowland Rice Plants

Based on the results of the analysis of variance, it was shown that the application of organic compost straw and inorganic fertilizers N, P, K, and Nano-silica made a significant difference to the K absorption and yield of lowland rice listed in Table 3 which was further tested by Duncan's multiple ranges with a level of 5%.

Table 3. Effect of Application of Straw Compost and N, P, K, Nano-silica Fertilizers on Potassium Uptake and Yields of Lowland Rice Plants

Treatment		Serapan K	GKP
		mg.tanaman^{-1}	g.tanaman^{-1}
A	Control	1,42 a	5,67 a
B	Kompos Jerami (5 ton per hektar) + ½ N, P, K, Nano-Silika	1,43 a	8,33 bc
C	Kompos Jerami (5 ton per hektar) + 1 N, P, K, Nano-Silika	1,84 cd	7,33 ab
D	Kompos Jerami (5 ton per hektar) + 1½ N, P, K, Nano-Silika	1,95 de	7,33 ab
E	Kompos Jerami (10 ton per hektar) + ½ N, P, K, Nano-Silika	1,49 a	6,67 ab
F	Kompos Jerami (10 ton per hektar) + 1 N, P, K, Nano-Silika	1,74 bc	11,00 d
G	Kompos Jerami (10 ton per hektar) + 1½ N, P, K, Nano-Silika	1,90 cd	8,00 bc
H	Kompos Jerami (15 ton per hektar) + ½ N, P, K, Nano-Silika	1,58 ab	8,33 bc
I	Kompos Jerami (15 ton per hektar) + 1 N, P, K, Nano-Silika	1,76 c	10,00 cd

J	Kompos Jerami (15 ton per hektar) + 1½ N, P, K, Nano-Silika	2,07 e	6,67 ab

Note: The mean value followed by the same letter in the same column is not significantly different based on Duncan's multiple range test at level 5%.

Potassium Absorption

Treatment D Straw Compost (5 tonnes per hectare) + 1½ N, P, K, Nano-Silica, J Straw Compost (15 tonnes per hectare) + 1½ N, P, K, Nano-Silica was significantly different from the Control treatment A (Without N, P, K, Nano-Silica and Straw Compost), B (Straw Compost (5 tonnes per hectare) + ½ N, P, K, Nano-Silica), E (Straw Compost (10 tons per hectare) + ½ N, P, K, Nano-Silica), and H (Straw Compost (15 tons per hectare) + ½ N, P, K, Nano-Silica). Straw compost, which is an organic fertilizer, has a role in providing K+ elements for plants by mineralizing organic matter which will supply K+ elements (Yuwono et al., 2002). The organic colloidal content which is negatively charged will temporarily bind K+ elements, so that the K+ elements given from inorganic fertilizers are not easily leached and will be fixed by clay minerals (Soepardi, 1983). K+ elements provided through fertilization will be maximally absorbed by plants. The application of K+ fertilizer, namely with KCl and straw compost will cause the soil and the area around plant roots to be saturated with K+ charges, so that the K+ concentration becomes higher. Osmotic diffusion causes K+ to be absorbed by plant roots and transferred to all plant tissues. According to Nunung's research (2012), states that straw compost can contribute a nutrient content of 1.20% K (Potassium) which is lost due to plant absorption and leaching.

Paddy Field Yield

The statistical analysis showed that treatment A (Control) had the lowest GKP value with a value of 5.67 g/plant, this was due to the absence of fertilization, so there was no additional input of macro and micro nutrients. In treatment C (Straw Compost (5 tonnes per hectare) + 1 N, P, K, Nano-Silica), D (Straw Compost (5 tonnes per hectare) + 1½ N, P, K, Nano-Silica), E (Straw Compost (10 tonnes per hectare) + ½ N, P, K, Nano-Silica), and J (Straw Compost (15 tonnes per hectare) + 1½ N, P, K, Nano-Silica) showed no significant differences between treatments his. Treatment B (Straw Compost (5 tonnes per hectare) + ½ N, P, K, Nano-Silica), G (Straw Compost (10 tonnes per hectare) + 1½ N, P, K, Nano-Silica), and H (Straw Compost (15 tonnes per hectare) + ½ N, P, K, Nano-Silica) were not significantly different either. Treatment F had a GKP value that was the highest compared to the other treatments, with an average value of 11.00 g.plant-1. This shows that the GKP results of lowland rice are related to the number of tillers in the plant. Based on the results of observations that treatment F had the highest average number of tillers, namely 21.87 tillers in the maximum vegetative phase (9 WAP). The number of tillers was influenced by the administration of Nano-silica which increased the production of the number of tillers, the number of panicles, the length of the panicles, and the number of grain compared to the control treatment. Application of nano-sized silica fertilizer can be more easily absorbed by plants because it has a relatively small size. This fertilizer has an active role in increasing enzymatic reactions in increasing the number of tillers and their weight thereby expanding the photosynthetic surface (Al-Juthery et al., 2020). Research conducted by Amalya et al. (2020), showed that the application of nano-silica can increase the absorption of sunlight so that the photosynthesis process increases and can increase the biomass and grain yield of rice plants. The application of silica fertilizer by spraying it directly on the plants through the leaves is called Foliar Application. According to Al-Khuzai and AL-Jutheri (2020), stated that the application of fertilizer with foliar application makes absorption more effective than applying fertilizer through the soil so that leaching does not occur.

Provision of sufficient K+ elements can improve the quality of rice, plants that lack K+ elements cause easy overturning which can ultimately reduce the quantity and quality of yields. Element K+ can also make plants more resistant to disease attacks, this is because element K can form phenolic compounds that are fungicidal and decrease the content of inorganic N in plant tissues. According to Lakudzala (2013), the K+ nutrient is related to the tissues in plants which are needed for the transportation of water, nutrients, and carbohydrates. Carbohydrates in plants that were previously stored in the stems and leaves are converted into sugar, then transported to the seed tissue and can increase the weight of plant seeds. If the rice plant is deficient in K+ elements, the cells will release exudate, the oxidation capacity will decrease. Based on Liebig's Minimum Law, that in increasing crop yields it is necessary to add fertilizer so that plants get the nutrients they need, plants have minimum levels so that the nutrient needs for photosynthesis are fulfilled. So, in the application of this type of dosage there is an optimal amount of input absorbed by rice plants (Mustaqim, 2018).

The process of photosynthesis has an important role after the stage of flower formation until the formation of grain. If the availability of sufficient K+ elements in the process of photosynthesis so that it can convert solar energy into chemical energy in the form of ATP. If the plant is deficient in K+, the translocation of carbohydrates from leaves to other organs is hampered, accumulation of photosynthesis that is not transported and reduces the ability of photosynthesis in plants.

CONCLUSION

The application of N, P, K, Nano-Silica and Straw Compost Fertilizer significantly increased CEC, K-dd, K Absorption, Plant Si, Si-Total and yield of black rice (Oryza sativa L.) on Ultisol soil. Dosage of Straw Compost Fertilizer (10 tons per hectare) and N, P, K fertilizer (250 kg Urea, 100 kg SP-36, and 100 kg KCl per hectare.), and Nano-silica (1 L/ha) gave the highest yield of Harvested Dry Grain worth 11.00 g.plant-1 and gave a yield increase of 94% compared to the control of 5.67 g.plant-1.

Acknowledge

We would like to thank the parties involved, supervisors, heads of the Faculty of Agriculture, and Padjadjaran University for the opportunity to carry out research by providing support in the form of institutional grants.

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